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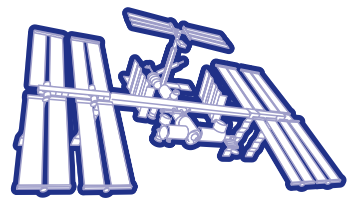
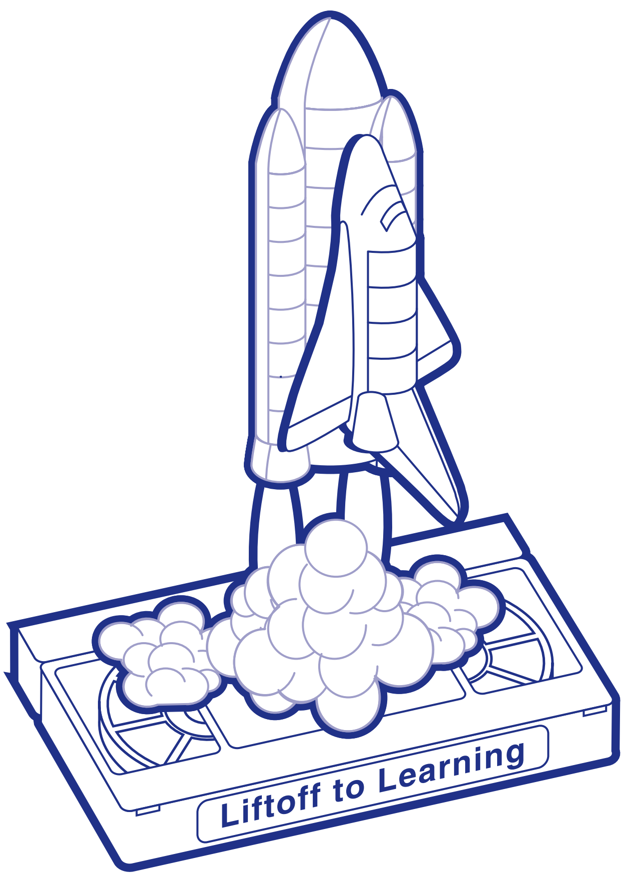


The Atmosphere Below

A Videotape for Earth and Space Science and Physical Science



Video Resource Guide

EV-1997-07-003-HQ

Video Synopsis

Title: The Atmosphere Below

Length: 16:02

Grade Level: 5-8

Subjects: Earth Science

Description: Changes in Earth's atmosphere are investigated from outer space onboard the Space Shuttle.

Science Standards:
Earth and Space Science
-Structure of the earth system
Physical Science
-Properties of objects and materials
Unifying Concepts and Processes
-Change, constancy, and measurement

Mathematics Standards:
Communication
Reasoning
Number and Number Relationships
Statistics
Measurement

Background

There are problems occurring in Earth’s atmosphere. Ozone holes, global warming, air pollution emissions, and predicted increases in skin cancers have caught the attention of scientists, environmentalists, and political leaders around the world. Many believe that important changes are taking place that could have a profound impact on all life. But much about the atmosphere is still unknown. It is a dynamic system of complex chemical and physical interactions. Because of its dynamic nature, the atmosphere is difficult to understand and model.

The atmosphere receives radiation from the Sun and is bombarded by a continuing stream of particles from the Sun and from deep space. Surrounding Earth is a magnetic field that captures electrically charged particles and brings them in contact with the atmosphere's upper reaches. The gases in the atmosphere absorb radiation and deflect wavelengths that could be harmful to life. Temperatures and chemical reactions vary widely through the atmosphere's different layers. Near Earth's surface, interactions take place with the land, the oceans, and with human-made pollutants. Furthermore, the atmosphere changes from day to night, season to season, and from the equator to the poles.

Atmospheric measurements taken at Earth's surface and from balloons and sounding rockets tell only part of the story. Scientists also need data gathered from the high vantage point of Earth orbit. In March of 1992, NASA embarked on an important new series of atmospheric studies made from space that take advantage of the unique capabilities of the Space Shuttle. These studies may help us answer some perplexing questions about the atmosphere's future as well as our own.

The Space Shuttle Atlantis carried the first of the Spacelab missions devoted to the study of the atmosphere. Onboard was the Atmospheric Laboratory for Applications and Science (ATLAS 1), a collection of 13 instruments designed to conduct 14 investigations in atmospheric science, solar science, space plasma physics, and astronomy for scientists from the United States, Belgium, France, Germany, Japan, Switzerland, and the Netherlands. From a 300-kilometer-high orbit inclined 57 degrees with respect to Earth's equator, the ATLAS 1 payload was in an advantageous position to observe the atmosphere, the Sun, and astronomical targets.

The crew of seven maneuvered the spacecraft and continuously controlled and monitored the experiments in consultation with investigators and planners on the ground.

Instruments and Purposes

During the 8-day mission, the instruments measured the total energy contained in sunlight and how that energy varies, measured the chemical composition of Earth's upper atmosphere, investigated how Earth's electric and magnetic fields and the atmosphere influence one another, and examined sources of ultraviolet light in the universe. Nine major instruments are listed below. They are grouped by main purpose. In the next section, these instruments are discussed in more detail.

Gases and aerosols:
Atmospheric Trace Spectroscopy instrument (ATMOS)
GRILLE Spectrometer
Solar Backscatter Ultraviolet instrument (SSBUV-A)

Solar radiation and atmospheric effects:
Solar Ultraviolet Irradiance Monitor (SUSIM)
Active Cavity Radiometer (ACR)
Measurement of Solar Constant instrument (SOLCON)
Millimeter Wave Atmospheric Sounder (MAS)

Auroras:
Space Experiments with Particle Accelerators (SEPAC)

Astronomy
Far Ultraviolet Space Telescope (FAUST)

Mission Results

The Atmospheric Trace Spectroscopy instrument surveyed atmospheric trace molecules by measuring the effects they have on infrared radiation. Similar measurements were also taken by the GRILLE Spectrometer. The data from these two instruments revealed aerosol bands in the atmosphere that were probably remnants of the Mt. Pinatubo volcanic eruption in the Philippines.

The Shuttle Solar Backscatter Ultraviolet (SSBUV-A) instrument has flown previously on three shuttle missions. The SSBUV-A is similar to instruments on Nimbus and TIROS (televison infrared satellite) satellites that measure ozone concentrations at various levels in the atmosphere. In time, data readings from these satellites fluctuate, making the accuracy of the readings suspect. Measurements taken by the SSBUV-A are being compared to those from the satellites to reestablish satellite instrument accuracy and to validate previously transmitted data.

In a similar vein, the Solar Ultraviolet Irradiance Monitor (SUSIM) and the Active Cavity Radiometer (ACR) provided data that will insure the continued accuracy of similar instruments on the Upper Atmosphere Research Satellite (UARS) which was launched in 1991 by the Space Shuttle Discovery. SUSIM made very accurate measurements of the Sun's ultraviolet radiation flow to learn how this radiation changes over time and relate those changes to changes in the atmosphere. The ACR instrument also measured ultraviolet radiation and, along with the Measurement of Solar Constant (SOLCON) instrument, provided a very accurate measure on the solar constant, the amount of energy the Sun constantly delivers to the atmosphere. Scientists theorize that changes in the constant of only 0.5 percent per century could lead to global climatic changes ranging from tropical to ice age conditions. The Millimeter Wave Atmospheric Sounder (MAS) instrument on ATLAS was also used for comparison with similar instruments on UARS. MAS recorded important measurements on ozone and chlorine monoxide, a key trace molecule involved in the destruction of ozone.

With two exceptions, all thirteen ATLAS 1 instruments had no major problems. In spite of blown fuses on two of the instruments (Far Ultraviolet Space Telescope or FAUST and Space Experiments with Particle Accelerators or SEPAC), all fourteen investigations supported by the instruments received significant data. The FAUST instrument provided astronomers with their first opportunity to explore wide areas of the sky in the far ultraviolet radiation wavelength range. Most ultraviolet light coming to Earth from space is filtered out by Earth's atmosphere, making it essential to travel into space to study this radiation firsthand. Previous space-flown ultraviolet instruments have focused on narrow regions of the sky. Before its power failure, FAUST observed the nearby Large Magellanic Cloud galaxy to gain information that may help astronomers better understand the evolution of our own galaxy. A gas trail behind the cloud was observed that could indicate a region of star formation. FAUST also made observations of galaxy clusters in the Virgo, Telescopium, Dorado, and Ophicus constellations.

The SEPAC instrument was used for controlled experiments that were successful in generating the first artificial auroras ever produced in Earth's upper atmosphere. By firing a 7.4 kilowatt electron beam into Earth's upper atmosphere, electrons circling atmospheric nitrogen and oxygen atoms and molecules were excited to higher energy levels. As they returned to lower levels, they released light, forming high intensity auroras several kilometers in diameter. Forty of the sixty beams produced artificial auroras and were imaged by the Atmospheric Emission Photometric Imaging experiment mounted in Atlantis's payload bay. The energy output of these auroras was greater than the energy input from the beam, indicating that the beam may have triggered larger reactions in the atmosphere. SEPAC was also used to investigate the interaction of ionized and neutral gases in space by injecting over 1,000 xenon gas clouds into the atmosphere. Furthermore, SEPAC generated radio waves with about 100,000 electron beam pulses. The pulses were observed by ATLAS 1 instruments and by over 100 receivers on the ground in the United States and Japan.

Terms

Atmospheric Laboratory for Applications in Science (ATLAS) - Series of Spacelab-based missions to study the nature of Earth's atmosphere, environmental problems, and the atmosphere's relationship to the outer space environment.

Carbon Dioxide - Molecule consisting of one atom of carbon and two of oxygen.

Chlorofluorocarbons - A series of human-made chemical compounds used in cooling and other application.

Global Warming - A suspected increase in world-wide temperatures.

Greenhouse Effect - Trapping of solar energy by gases in Earth's atmosphere.

Methane - Molecule consisting of one atom of carbon and four of hydrogen.

Oxides of Nitrogen - A group of molecules consisting of nitrogen and oxygen.

Ozone - Molecule of oxygen consisting of three atoms of oxygen.

Ozone Depletion - The destruction of upper atmosphere ozone molecules through the action of human-made chemicals and sunlight.

Ultraviolet Radiation - Short wave electromagnetic radiation just beyond the visible violet light.

Upper Atmosphere Research Satellite (UARS) - Scientific satellite launched by the STS-48 mission in 1991.

Classroom Activities

These activities will help your students understand the material in "The Atmosphere Below." In both activities students investigate properties of the atmosphere.

Balloon Science

Materials

Two small latex balloons
Two 15-cm pieces of string
30.5-cm ruler
Piece of notebook paper
Tape

Background

Earth's air has many characteristics. Scientists have developed different ways of investigating these characteristics. In this exercise students will investigate an important question about air: Does it have weight?

Procedure

Attach a balloon to each end of a ruler, being careful to use exactly the same lengths of string or tape to attach each balloon. Suspend the ruler on a string at approximately the 15-cm mark to create a balance. With tape, attach the top of the string to a wall about eye level. Tape the notebook paper to the wall behind the ruler. Put a pencil mark on the paper above and below each end of the ruler to mark its beginning position. Remove one of the balloons and blow into it, inflating it as much as possible. Tie and reattach the balloon with the same piece of string. Gently pull the string suspending the ruler away from the wall, allowing the ruler to readjust. Carefully release the string and check the ruler's new position. Mark the paper with the pencil again.

Discussion

1. Does the ruler still balance?
2. Does one balloon now weigh more than the other?
3. What does this tell you about air?
4. Was your hypothesis correct? When a number of different experiments give the same results, the hypothesis may be accepted as a theory.

Extension

1. Determine the weight of the air in the balloon. (To do this, the students just have to weigh the balloon uninflated, then inflated and subtract the first number from the second.)
2. Determine the weight density of the air in the balloon. (Find the volume of air by using a similar balloon. Put water into it until it has about the same size as the balloon with air. Then measure the volume of water; this will be about the same as the volume of air. Divide this number into the air's weight from Extension 1. This is the weight density of the air.)

Nothing But the Truth

Materials
Daily newspapers
Pencils or pens

Background
All the mysteries that ATLAS 1 scientists investigated involve possible causes of atmospheric changes. To obtain the most accurate information, researchers must measure chemicals at different altitudes in the atmosphere in sunlight and in darkness, and during all seasons for many years. Even then, scientists have more questions: Are the instruments measuring accurately? What were conditions nearer the ground when measurements were made from space? How are conditions in the middle atmosphere related to events in the troposphere? To help answer these questions, researchers use airplanes, balloons, rockets, and ground measurements to double check and add to data obtained from space. These efforts are called ground-truth studies and make remotely sensed data even more accurate and important. You, too, can perform ground-truth studies.

Procedure
Check the newspaper daily and record information on temperature highs and lows, amount of precipitation and humidity. Keep these charts, and as the year progresses, figure weekly and monthly averages for your area. You may want to compare these with figures from previous years using an almanac or examining old newspapers in the microfiche section of your library. You might also want to make your own measurements of rainfall, snowfall, and high and low temperatures. Different groups may want to select forecasters on several radio or TV stations to determine which predicted results are closest to those actually measured.

Discussion
1. What do you notice about temperature highs and lows, precipitation, and humidity throughout the year?
2. Do these seasonal variations mean that the climate is changing?
3. If you investigate measurements from past years, do changes necessarily mean that the climate is changing?
4. How accurate are the weather forecasts in your area?

Extension
Calculate weekly, monthly, and yearly averages of temperature and rainfall in your area. Make a bar chart showing average temperatures for each time span. Another important statistic is how much temperature and rainfall changes differ from the average. This difference is called the “standard deviation” because it measures how much something “deviates” or differs from the average.

Date	High Temp.	Low Temp.	Precipitation	Humidity
Daily Average				

References

NASA On-line Resources for Educators provide current educational information and instructional resource materials to teachers, faculty, and students. A wide range of information is available, including science, mathematics, engineering, and technology education lesson plans, historical information related to the aeronautics and space program, current status reports on NASA projects, news releases, information on NASA educational programs, useful software and graphics files. Educators and students can also use NASA resources as learning tools to explore the Internet, access information about educational grants, interact with other schools, and participate in on-line interactive projects, communicating with NASA scientists, engineers, and other team members to experience the excitement of real NASA projects.

Access these resources through the NASA Education Home Page:
http://education.nasa.gov

Other web sites of interest:
http://www.ksc.nasa.gov/shuttle/missions/sts-45/mission-sts-45.html
http://www.hq.nasa.gov/office/mtpe

NASA Publications

ATLAS Educator Slide Set, National Aeronautics and Space Administration, Education Division, 1991.

Other Publications

The Greenhouse Effect, United States Department of Energy, 1991.

Rosenthal, D., Golden, R., Global Warming High School Science Activities, Climate Protection Institute, 1991.

Snow, R., Golden, R., Global Warming Social Studies Activities, Climate Protection Institute, 1991.

USA Today, Earth Today - Your Place in the Environment, Teacher's Guide, Gannett Co. 1990.

Sunlight, Earthwise Environmental Learning Series, V1n2, WP Press, 1992.

STS-45 Crew Biographies

Charles F. Bolden, Jr. (Col., USMC). Charles Bolden was born in Columbia, SC. He earned a bachelor of science degree in electrical science from the United States Naval Academy and a master of science in systems management from the University of Southern California. After graduation, Bolden became a naval aviator and later a test pilot. He has logged more than 5,000 hours flying time. Bolden became an astronaut in 1981 and has flown in space twice previously, as pilot of the STS-61C and STS-31 missions.

Brian Duffy (Lt. Col., USAF). Brian Duffy was born in Boston, MA. He received a bachelor of science degree in mathematics from the U.S. Air Force Academy and a master of science degree in systems management from the University of Southern California. Upon graduation Duffy completed pilot and test pilot training. Duffy became an astronaut in 1986. This was his first spaceflight.

Kathryn D. Sullivan (Ph.D.). Kathryn Sullivan was born in Paterson, NJ, but considers Woodland Hills, CA, her home. She earned a bachelor of science degree in Earth sciences from the University of California, Santa Cruz, and a doctorate in geology from Dalhousie University (Halifax, Nova Scotia). Dr. Sullivan is an oceanography officer in the U.S. Naval Reserve and an Adjunct Professor of Geology at Rice University, Houston, Texas.
Dr. Sullivan became an astronaut in 1979 and has flown previously as a mission specialist on STS-41G and on STS-31.

David C. Leestma (Capt., USN). David Leestma was born in Muskegon, MI. He graduated from the U.S. Naval Academy and earned a master of science degree in aeronautical engineering from the U.S. Naval Postgraduate School. He then became a naval aviator. Prior to this mission, Leestma served as a mission specialist on the crews of STS-41G and STS-28.

C. Michael Foale (Ph.D.). Michael Foale was born in Louth, England, but considers Cambridge, England, to be his hometown. He attended the University of Cambridge, Queens' College, receiving a bachelor of arts degree in physics and a doctorate in laboratory astrophysics. Foale joined NASA Johnson Space Center in 1983 in the payload operations area of the Mission Operations Directorate. He was selected as an astronaut in 1987. This was his first spaceflight.

Byron K. Lichtenberg (Sc.D.). Byron Lichtenberg was born in Stroudsburg, PA. He received a bachelor of science degree in aerospace engineering from Brown University, a master of science degree in mechanical engineering from Massachusetts Institute of Technology (MIT), and a doctorate in biomedical engineering from MIT. Upon receiving his undergraduate degree, Lichtenberg entered the Air Force and became a pilot. He served as a payload specialist on the STS-9 (Spacelab-1) mission. This was his second flight.

Dirk D. Frimout (Ph.D.). Dirk Frimout was born in Poperinge, Belgium. He received the degree of electrotechnical engineer at the State University of Ghent (Belgium) and a doctorate in applied physics from the University of Ghent. He performed post-doctoral work at the University of Colorado, Laboratory of Atmospheric and Space Physics.

Dr. Frimout is senior engineer in the Payload Utilization Department of the Columbus Directorate of the European Space Agency (ESA) and has been responsible for ESA support to the European experiments on ATLAS-1 since 1985. He was selected as a flight payload specialist in 1991. This was Dr. Frimout's first spaceflight.

NASA Liftoff to Learning
The Atmosphere Below

EDUCATOR REPLY CARD
Video Resource Guide

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http://ehb2.gsfc.nasa.gov/edcats/educational_videotape

You will then be asked to enter your data at the appropriate prompt.

Otherwise, please return the reply card by mail. Thank you.

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3. This is a valuable video and video resource guide.
   ❑ Strongly Agree ❑ Agree ❑ Neutral ❑ Disagree ❑ Strongly Disagree

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   ❑ Excellent ❑ Good ❑ Average ❑ Poor ❑ Very Poor

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